

**2011 ADEM GROUNDWATER CONFERENCE
JUNE 8, 2011**

**MULTIPLE REMEDIATION STRATEGIES
FOR HALOGENATED HYDROCARBONS
IN FRACTURED LIMESTONE**

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OUTLINE

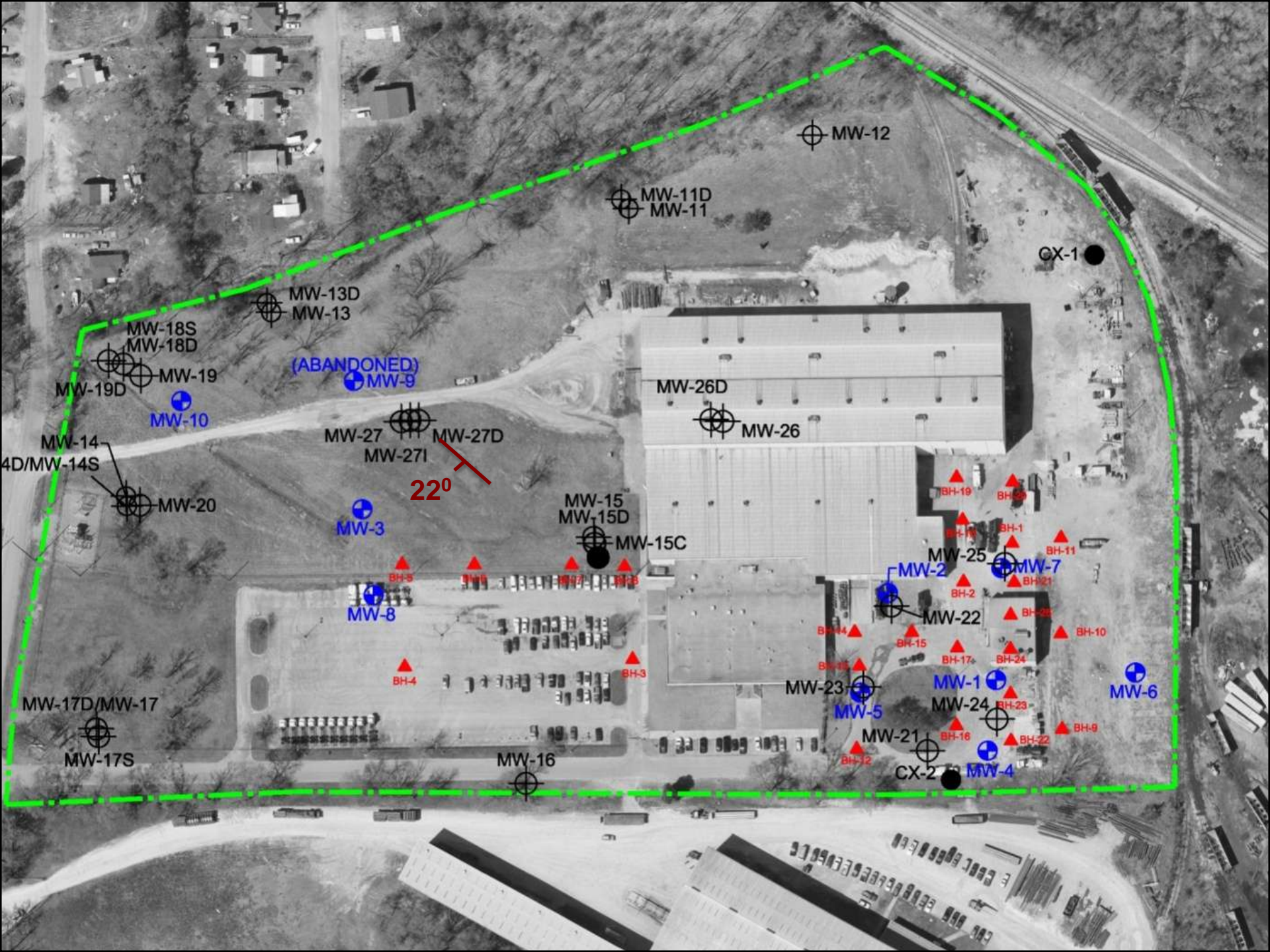
- Since 1975, site operators manufactured specialized equipment and assembled utility trucks.
- Since 2004 PELA conducted a series of investigations as:
 - Geological Mapping.
 - Geo-Probe, Mud Rotary, Air Rotary drilling methods and geophysical logging were used during soil sampling, coring, and well installation.
 - Interpretation of hydrogeologic and subsurface information.
 - Preparation and interpretation of contours maps of various halogenated hydrocarbons, and ground-water elevation maps for shallow and deep wells, with emphasis on Paint Shop Area and Southwest Corner of the property.
 - Pilot remediation system test and bench scale bioremediation study were initiated and completed.

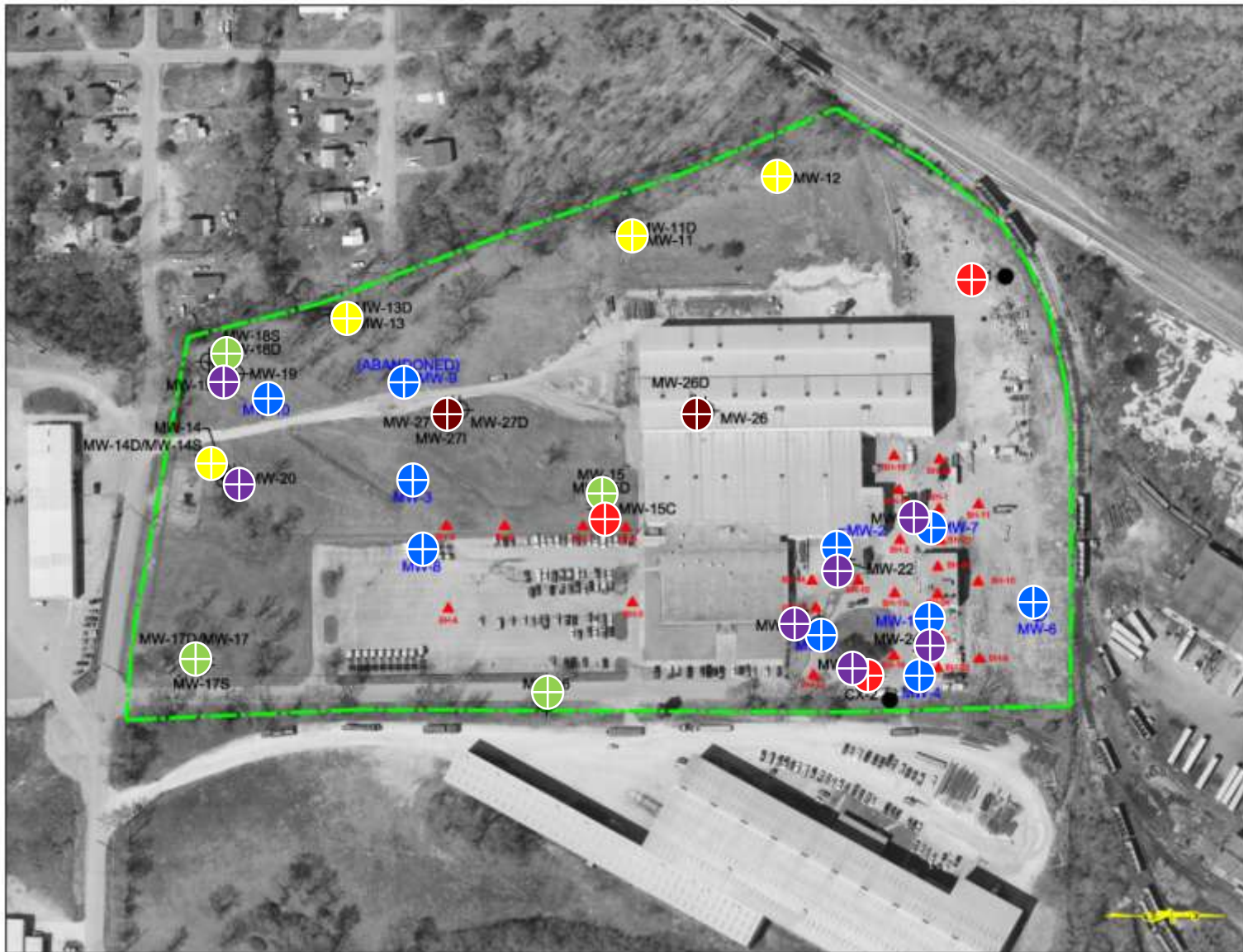


**The site is underlain by the Cambrian age
Conasauga Limestone**



At the site the limestone strike is N. 25° E. to N. 30° E., and the dip is 20° to 23° SE.





23 shallow and 15 deep wells were installed



Geo-Probe soil sampling



Hollow Stem Augers



Soil sampling, 5 foot sampler inside hollow stem auger



Rock coring



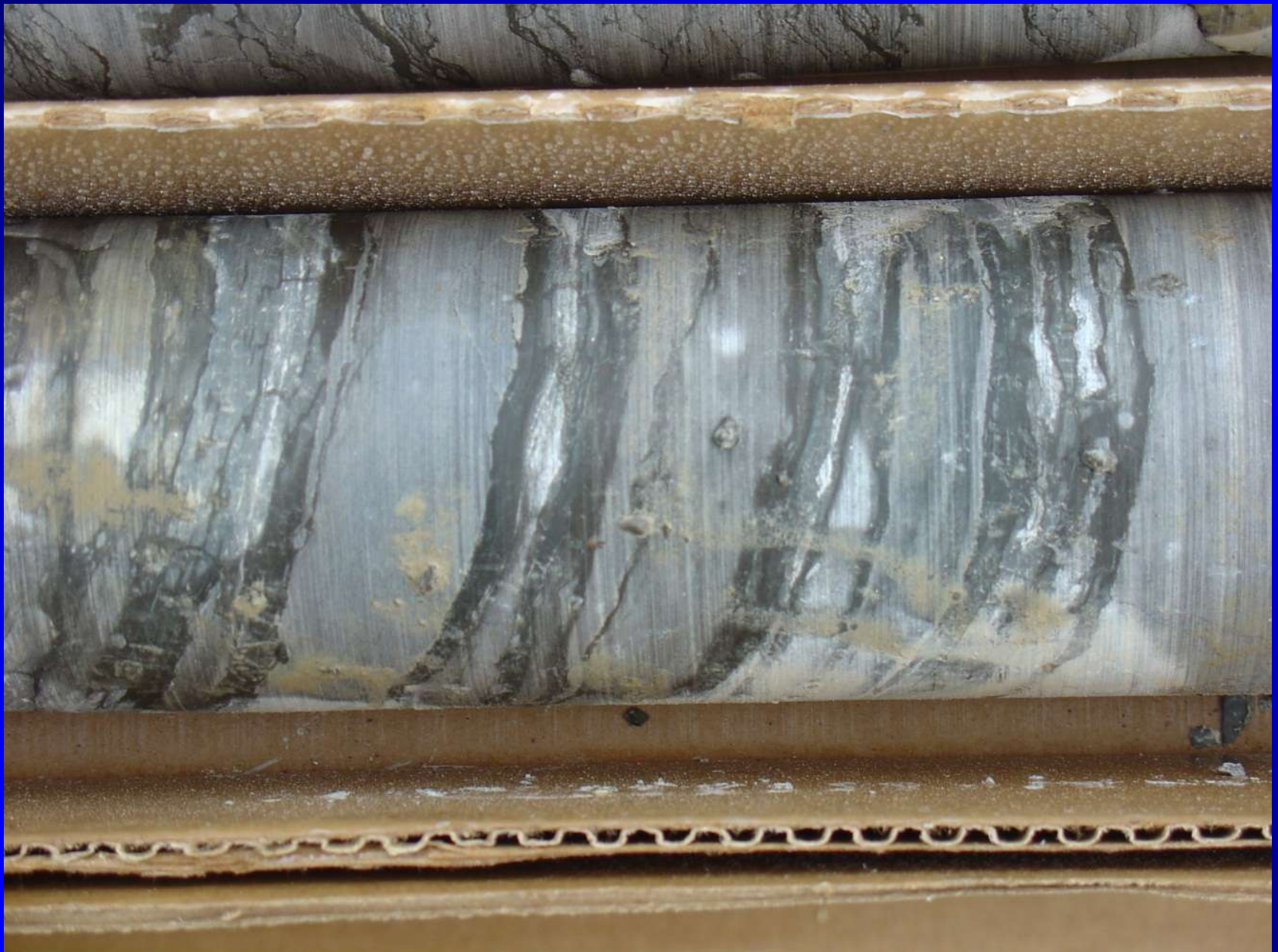
Air drilling - inside a building



Air drilling - no water yet



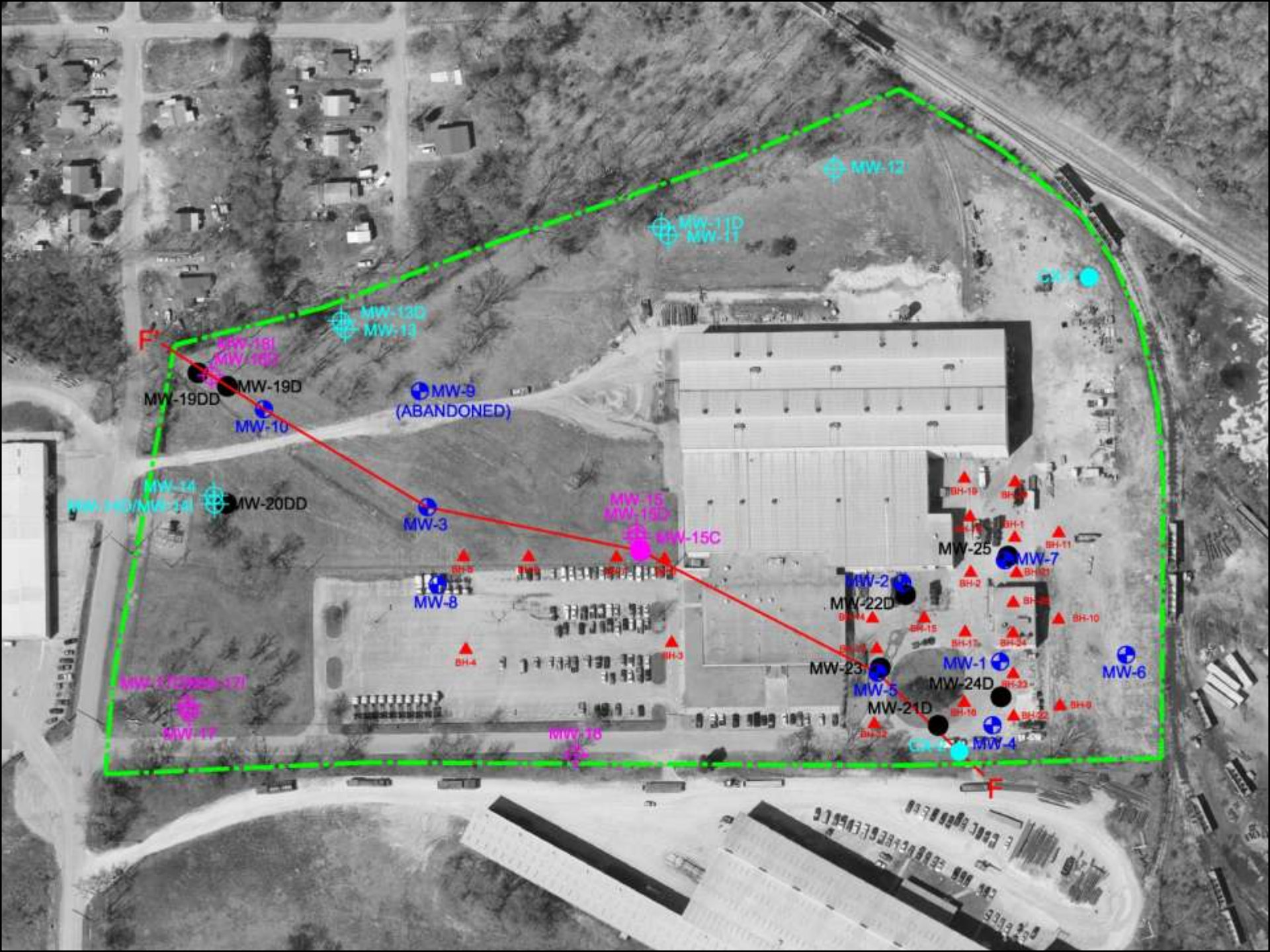
The Conasauga Formation exhibits little or no porosity

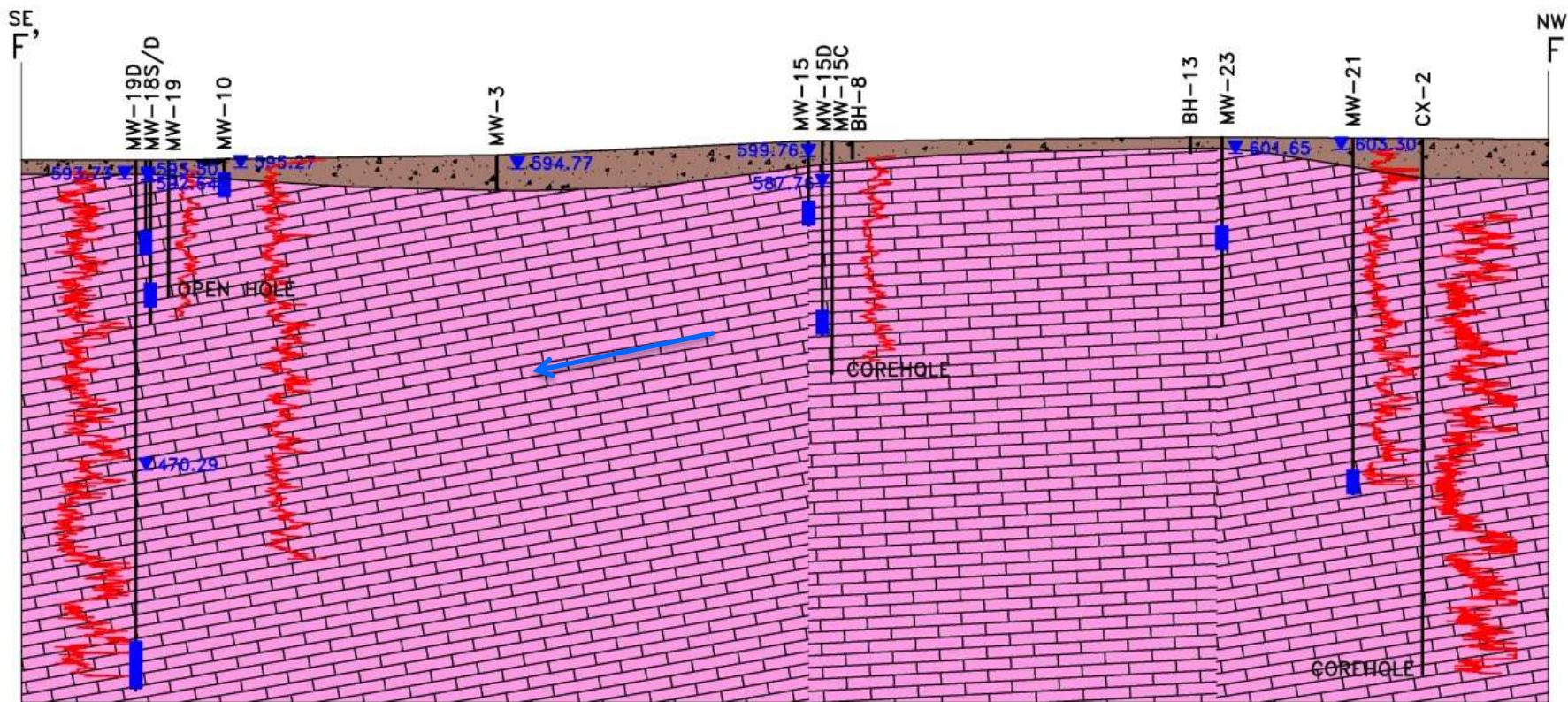


No primary porosity in the bedrock



Ground-water movement occurs along solutionally enlarged fractures of limited size (up to 16 cm) and bedding planes

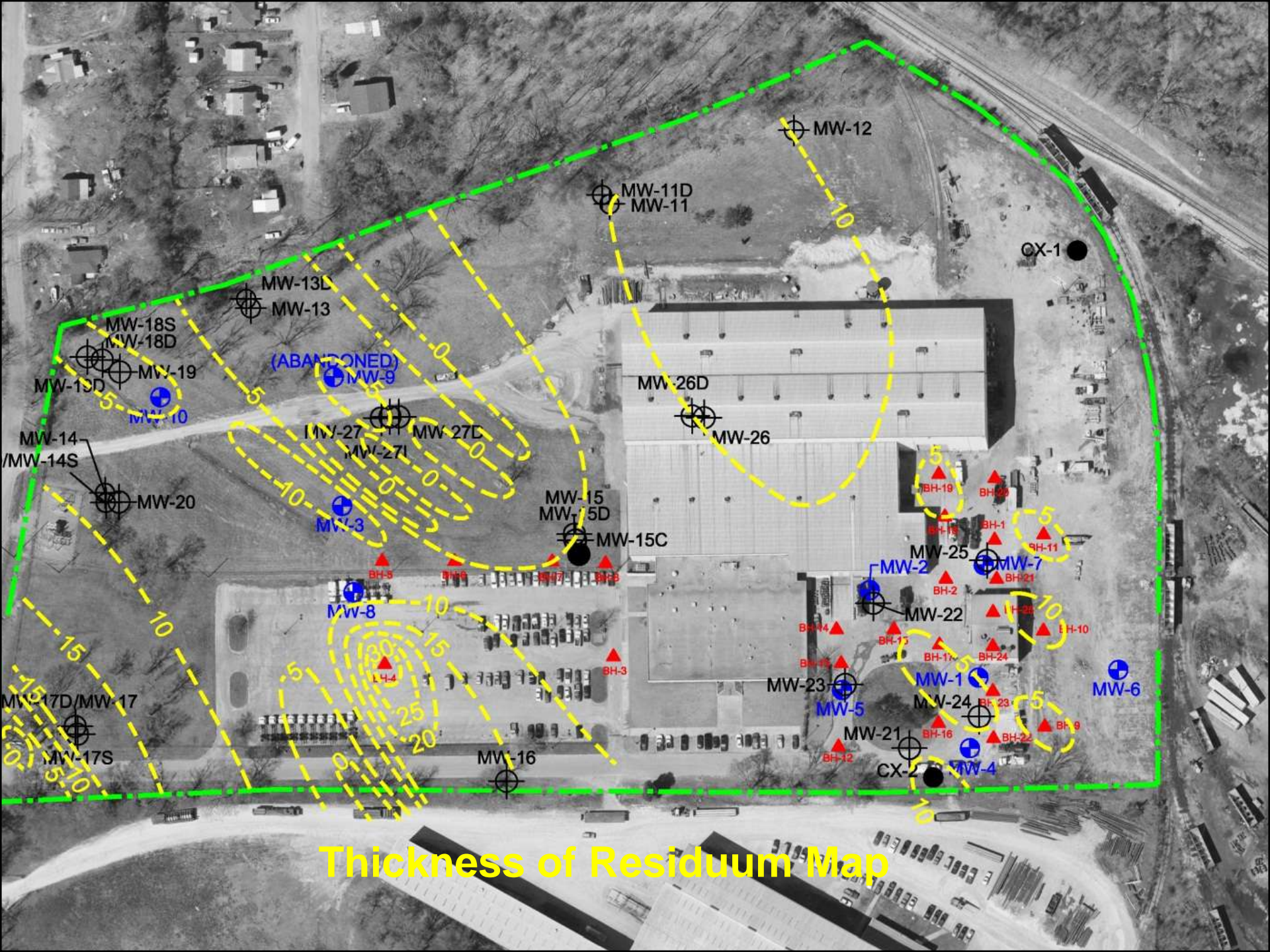




▼ 591.65 WATER LEVEL ON JAN 15, 2007



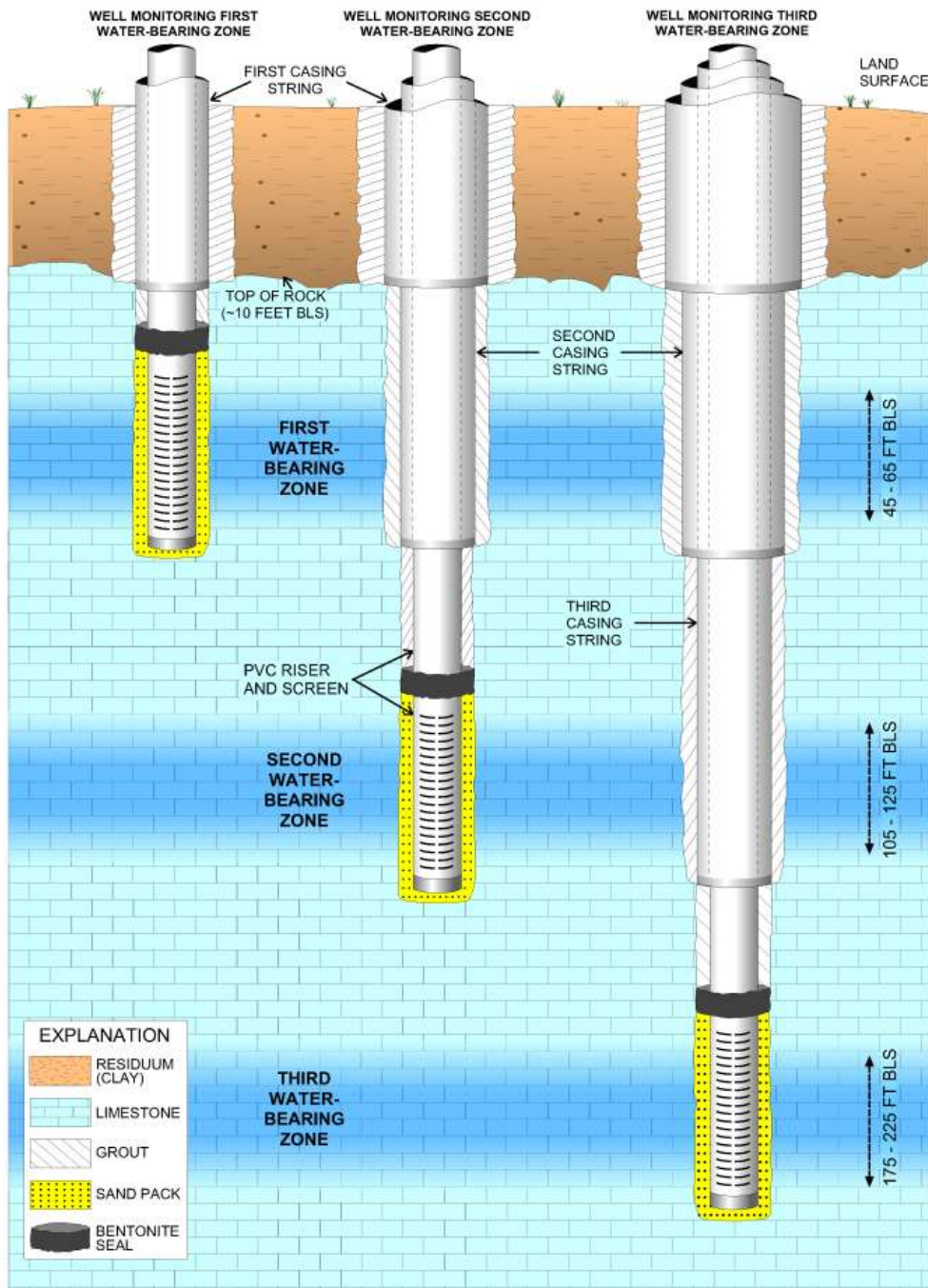
AMMA RAY)



Thickness of Residuum Map



Well Construction



Bedrock Wells

Type I Well

Type II Well

Type III Well



Type III (telescoping) Well



Water sampling



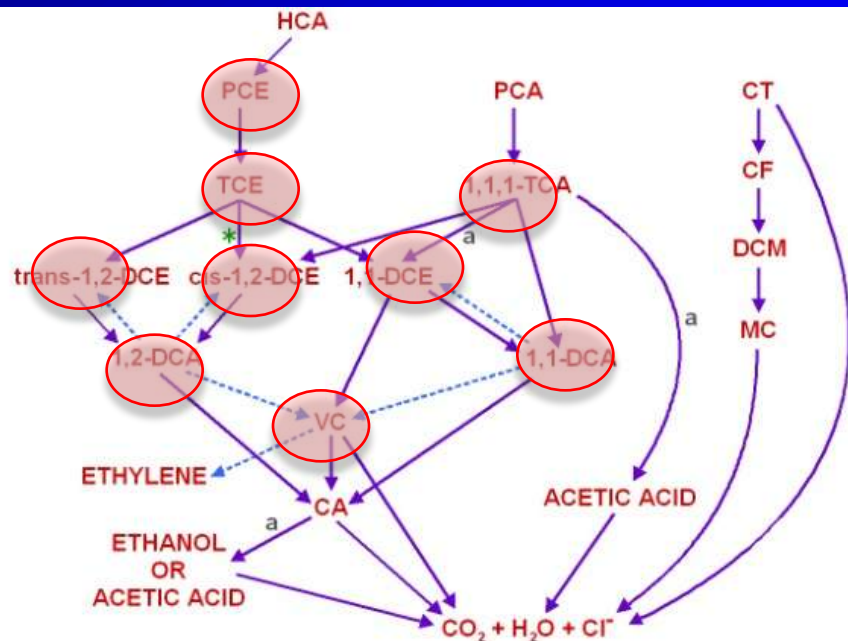
Water sampling





Cuttings, development water, and purged water were contained and properly disposed





HCA: HEXACHLOROETHANE (C_2Cl_6)
 PCE: TETRACHLOROETHYLENE (C_2Cl_4)
 PCA: TETRACHLOROETHANE (C_2HCl_3)
 CT: CARBON TETRACHLORIDE (CCl_4)
 TCE: TRICHLOROETHYLENE (C_2HCl_3)
 1,1,1-TCA: 1,1,1-TRICHLOROETHANE ($\text{C}_2\text{H}_2\text{Cl}_3$)
 CF: CHLOROFORM (CHCl_3)
 trans-1,2-DCE: trans-1,2-DICHLOROETHYLENE ($\text{C}_2\text{H}_2\text{Cl}_2$)
 cis-1,2-DCE: cis-1,2-DICHLOROETHYLENE ($\text{C}_2\text{H}_2\text{Cl}_2$)
 1,1-DCE: 1,1-DICHLOROETHYLENE ($\text{C}_2\text{H}_2\text{Cl}_2$)
 DCM: DICHLOROMETHANE (CH_2Cl_2)
 MC: METHYL CHLORIDE (CH_3Cl)
 1,2-DCA: 1,2-DICHLOROETHANE ($\text{C}_2\text{H}_4\text{Cl}_2$)
 1,1-DCA: 1,1-DICHLOROETHANE ($\text{C}_2\text{H}_4\text{Cl}_2$)
 VC: VINYL CHLORIDE ($\text{C}_2\text{H}_3\text{Cl}$)
 ETHYLENE: (C_2H_4)
 CA: CHLOROETHANE ($\text{C}_2\text{H}_5\text{Cl}$)
 ETHANOL: ($\text{C}_2\text{H}_5\text{OH}$)
 ACETIC ACID: ($\text{C}_2\text{H}_4\text{O}_2$)

FROM BARBEE, 1994

— PRIMARY TRANSFORMATION PATHWAY
 - - - SECONDARY TRANSFORMATION PATHWAY
 a INDICATES ABIOTIC CHEMICAL TRANSFORMATION; OTHER
 ARROWS REPRESENT BIOLOGICAL TRANSFORMATIONS
 * cis-1,2-DCE GENERATED AT APPROXIMATELY 30 TIMES THE
 CONCENTRATION OF trans-1,2-DCE, AND BY A FACTOR OF 25:1

FIGURE 41. CHEMICAL AND BIOLOGICAL TRANSFORMATION PATHWAYS OF SELECTED CHLORINATED HYDROCARBONS UNDER ANAEROBIC CONDITIONS

FIGURE 2. TOTAL ORGANIC COMPOUNDS IN GROUND WATER-DEEP WELLS, JANUARY 2007

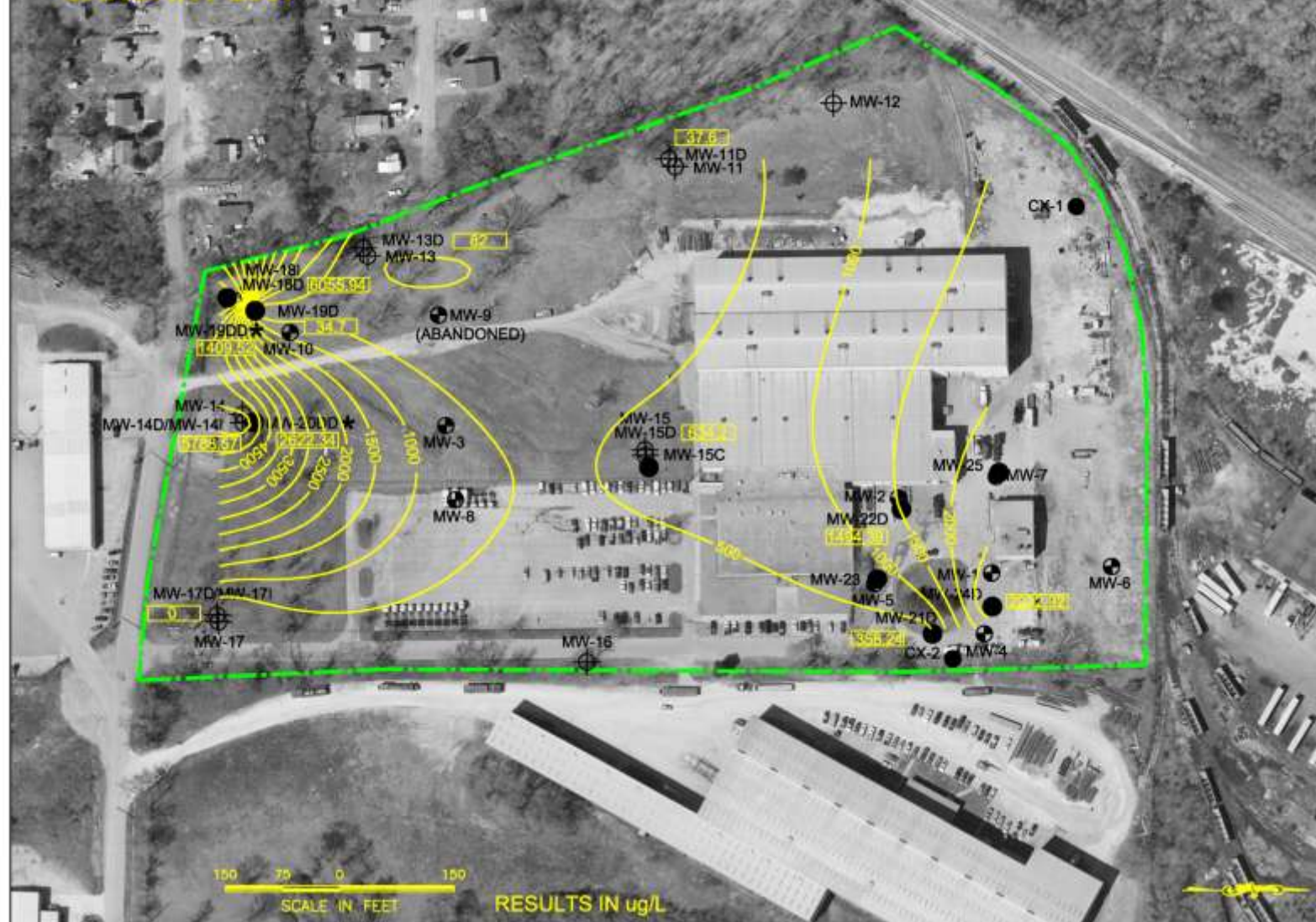
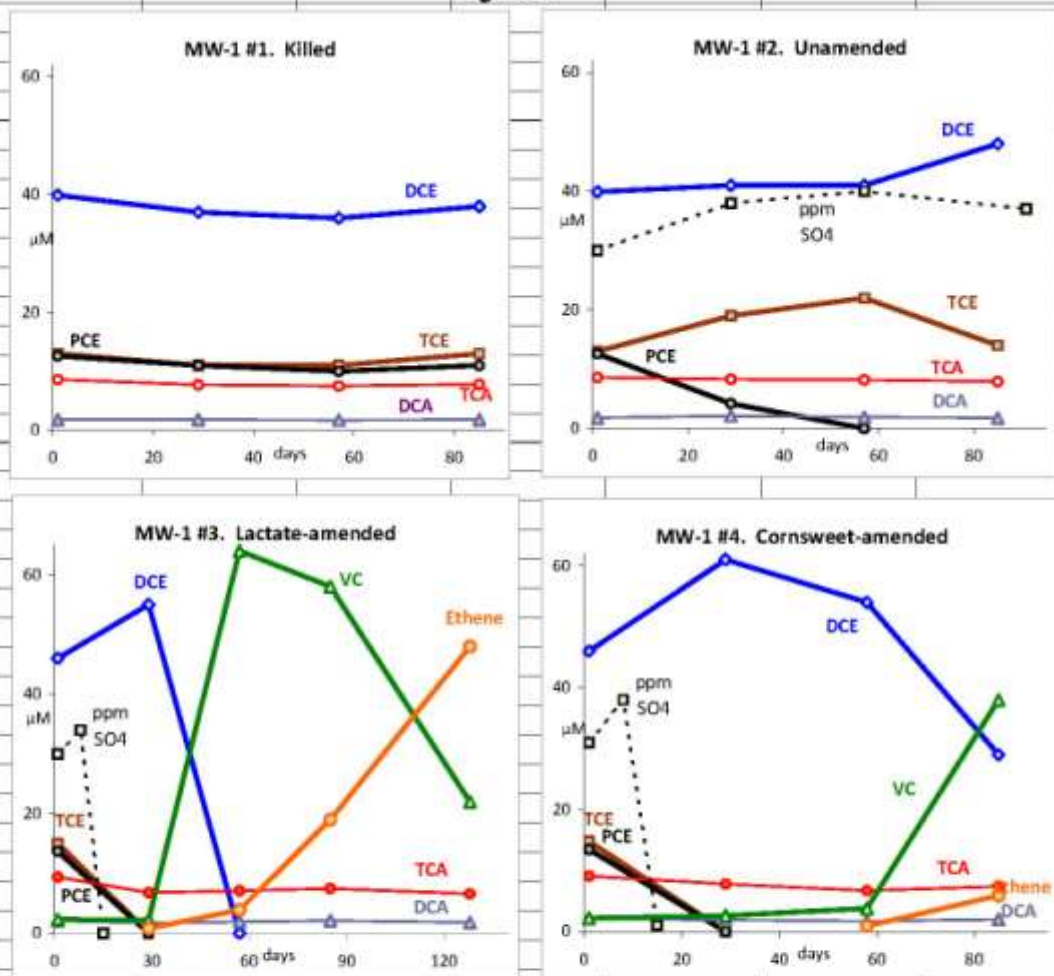




Figure 1

Bioremediation-Microcosm Study Anaerobic Reductive Dechlorination (Environmental Alliance)

PAINT SHOP AREA (SHALLOW CONTAMINATION)

TEST CONDITIONS:

- Killed Control-pH was adjusted to 2
- Unamended Control-Evaluate natural conditions at the site
- Sodium lactate Amended
- Corn Sweet Amended
- Bioaugmented and amended with Sodium Lactate and Corn Sweet

RESULTS:

• Dechlorinating bacteria (Dehalo-coccoides) are present in the aquifer capable of dechlorinating PCE and TCE to ethene using the proper donor substrate (lactate or corn sweet)

SOUTHWEST CORNER (DEEP CONTAMINATION)



Accelerated Remediation Technology (ART) Well Head



Well Head



Pilot Test Remediation System

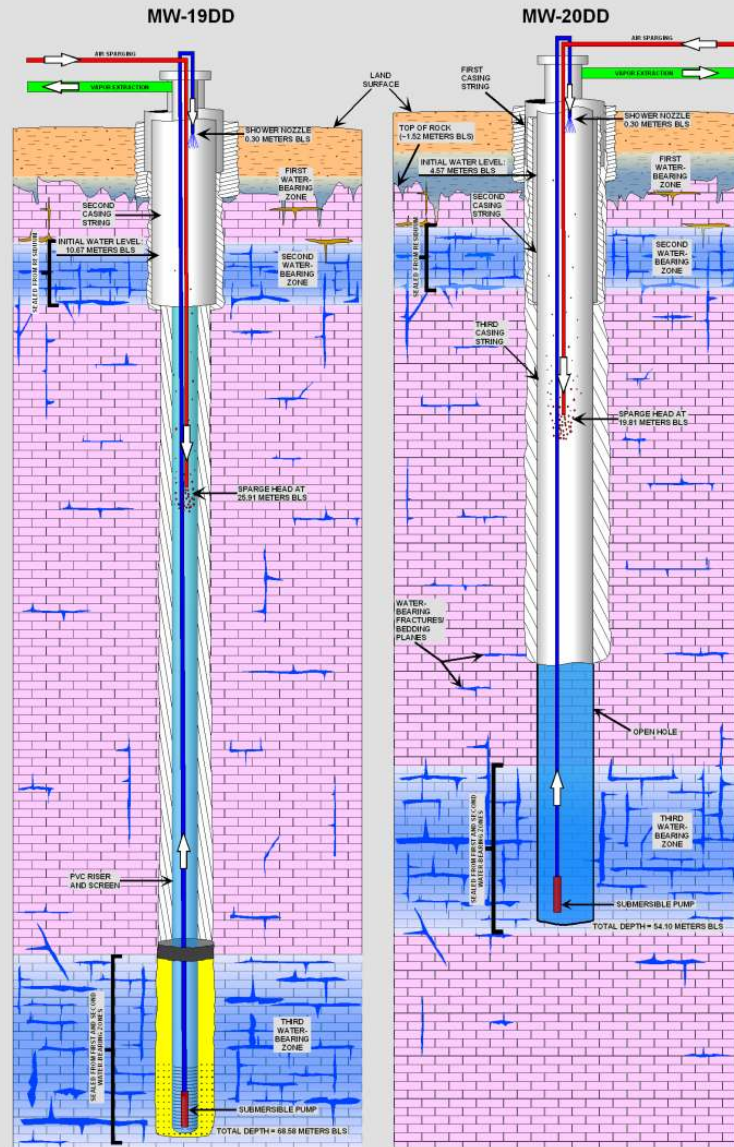


Air compressor (left)-Vacuum Pump (right)



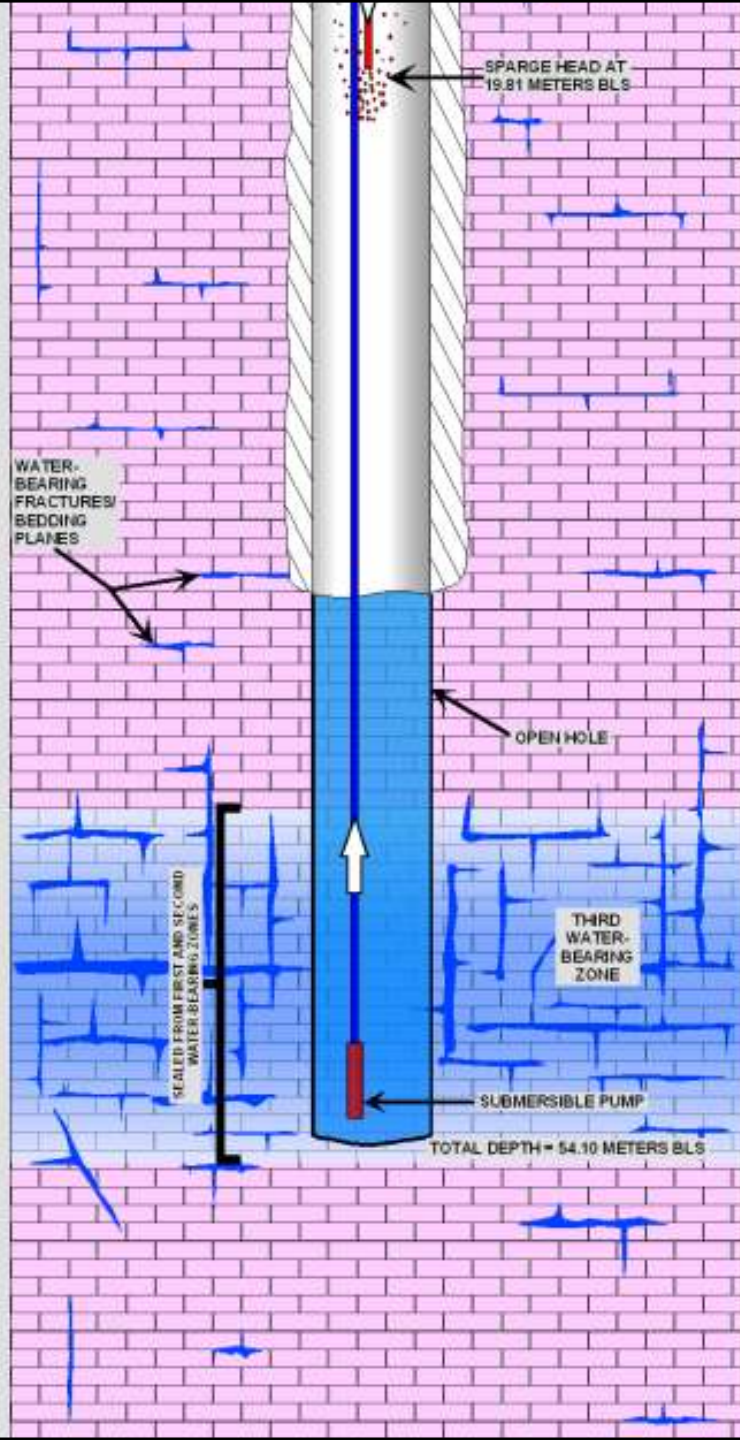
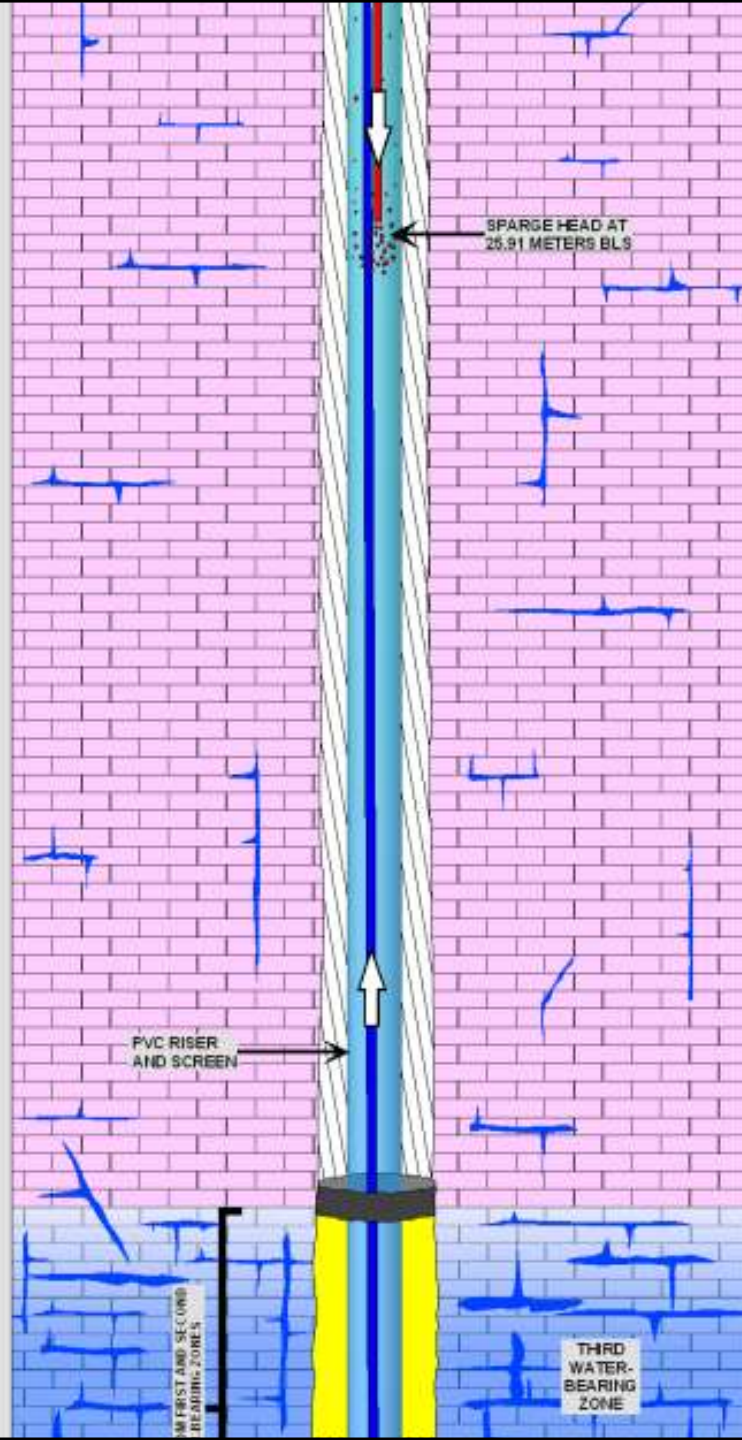
Air in-red hose; vacuum out - white 2" PVC pipe

FIGURE 5. SCHEMATIC OF PILOT TEST WELLS

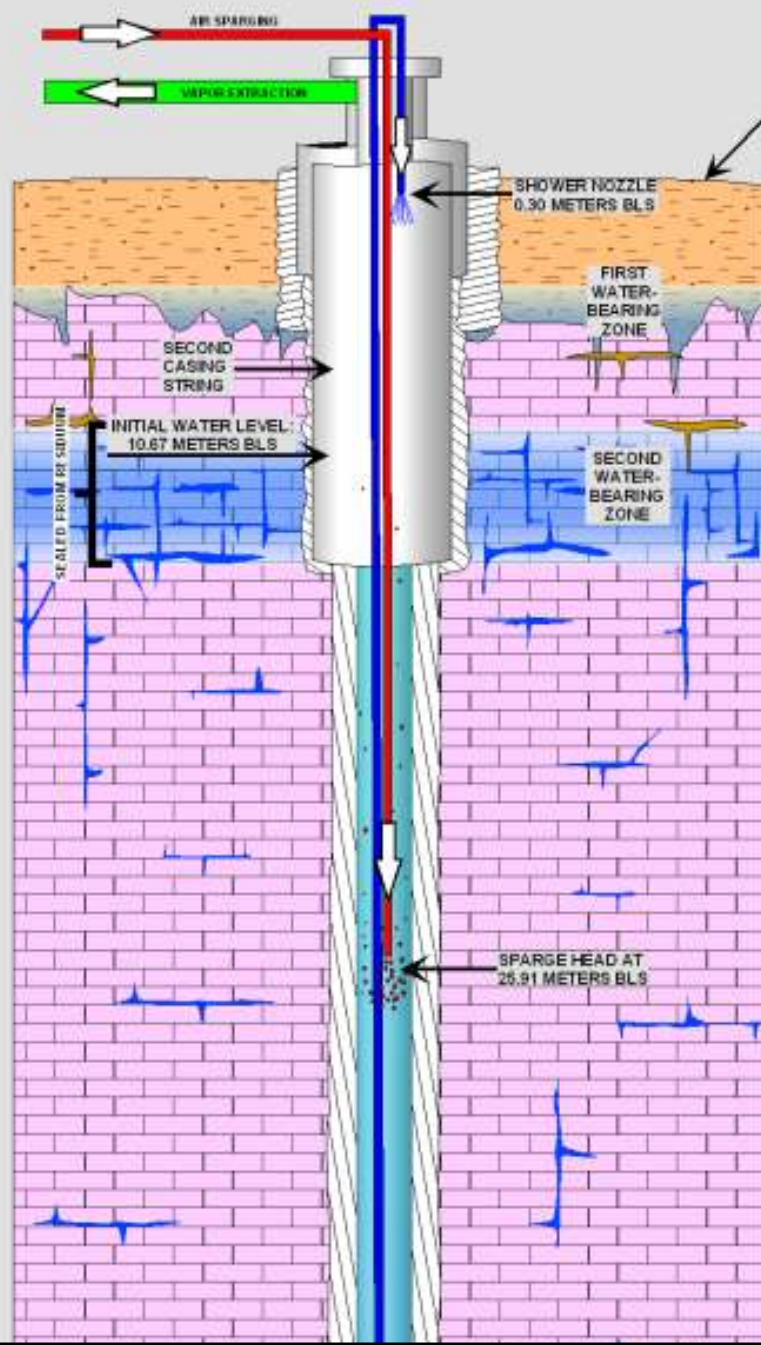


WELLHEAD AND TEST SYSTEM – ACCELERATED
REMEDiation TECHNOLOGIES (ART) INC.,
IN-WELL TECHNOLOGY

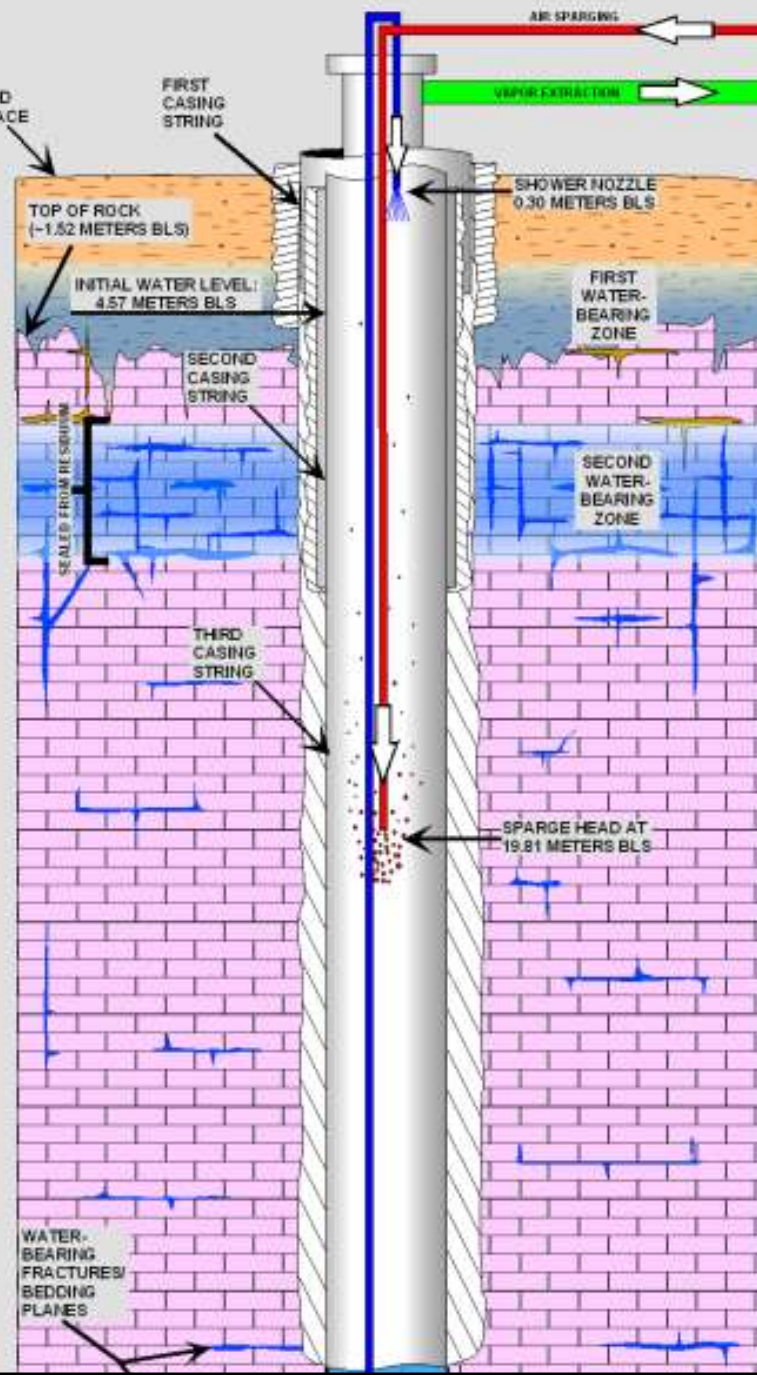
EXPLANATION	
	RESIDUUM (CLAY)
	LIMESTONE
	GROUT
	SAND PACK
	BENTONITE SEAL



MW-19DD



MW-20DD



Results in ug/L

LOCATION	DATE	TOTAL ORGANIC COMPOUNDS (TOC)
MW-19DD	01/15/07	1409.52
MW-19DD	09/29/09	97.86
MW-19DD	02/23/10	114.38
INITIATION OF THE PILOT TEST APRIL 15 , 2010		
MW-19DD	04/15/10	300.70
MW-19DD	05/26/10	0.00
MW-19DD	06/21/10	0.00
MW-19DD	06/24/10	5.68
END OF THE PILOT TEST JULY 15, 2010		
MW-19DD	08/24/10	4.69
MW-19DD	10/28/10	12.81
MW-20DD	01/16/07	2622.34
MW-20DD	09/29/09	35.77
MW-20DD	02/23/10	1994.57
INITIATION OF THE PILOT TEST APRIL 15 , 2010		
MW-20DD	04/15/10	1010.23
MW-20DD	05/26/10	0.0013
MW-20DD	06/21/10	0.00
MW-20DD	06/24/10	3.98
END OF THE PILOT TEST JULY 15, 2010		
MW-20DD	08/24/10	9.47
MW-20DD	10/28/10	24.85

MAJOR COMPONENTS OF TOC

VINYL CHLORIDE
 1,1-DICHLOROETHENE
 1,1-DICHLOROETHANE
 CIS 1,2 DCE
 TRANS 1,2 DCE
 CIS-1,2-DICHLOROETHENE
 1,1,1-TRICHLOROETHANE
 1,1,2,2 TCA
 CHLORO-ETHANE
 BENZENE
 TRICHLOROETHENE
 TOLUENE
 METHYL BROMIDE
 METHYL. CHLORIDE



THANK YOU!